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CASSAVA.

BY

S. M. TRACY, M. S.,

Formerly Director of the Mississippi Agricultural Experiment Station.

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
Washington, D. C., January 31, 1903.

SIR: I have the honor to transmit herewith a paper on Cassava, and respectfully recommend that it be published as a farmers' bulletin. The paper was prepared by Prof. S. M. Tracy, formerly director of the Mississippi Experiment Station, who is already well known as a writer in this field of agricultural work, and it was submitted to me by the Agrostologist.

Attention is particularly directed to the fact that outside of an area extending 100 miles from the coast of the States of Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, and possibly South Carolina, it will be useless to attempt to grow cassava with success.

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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CASSAVA.

INTRODUCTION.

Cassava is cultivated for its starchy roots, which are used extensively for human food, especially in the Tropics, as food for live stock, and for the manufacture of starch. It belongs to the milkweed family (*Euphorbiaceæ*) and is a native of Brazil, whence it has been carried to nearly all the warmer parts of the world.

VARIETIES OF THE PLANT.

Although two principal forms of the plant are named, the "bitter" (*Manihot utilissima* Pohl.) and the "sweet" (*Manihot aipi* Plon.), the

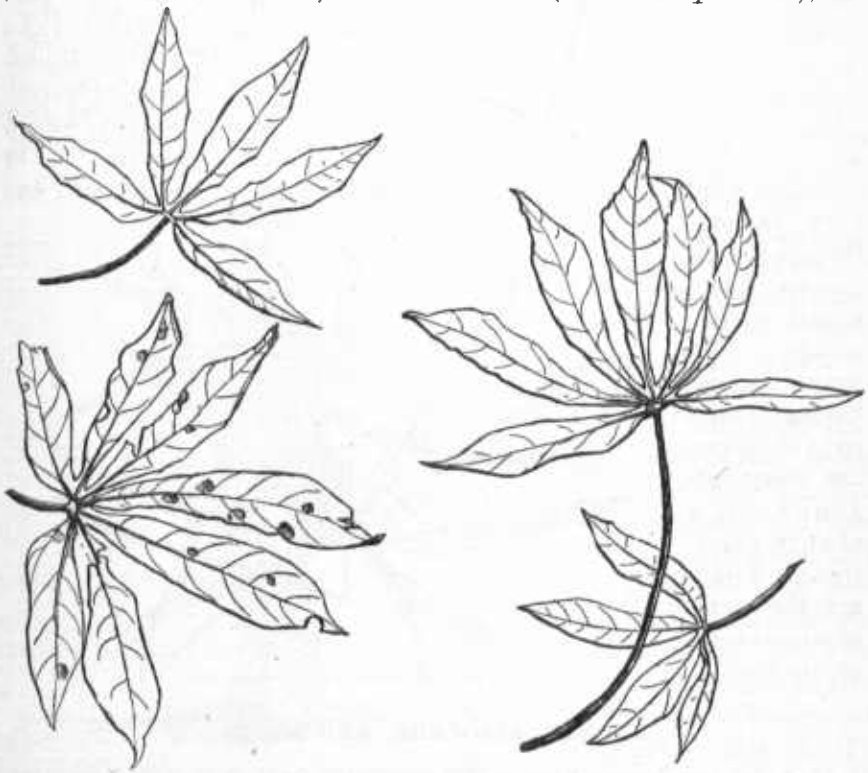

FIG. 1.—Ordinary forms of cassava leaves.

specific differences between the two are so slight and inconstant that it is more than probable that the many forms which now exist have

been developed by centuries of cultivation under widely different conditions and that all the present cultivated varieties belong to a single species.

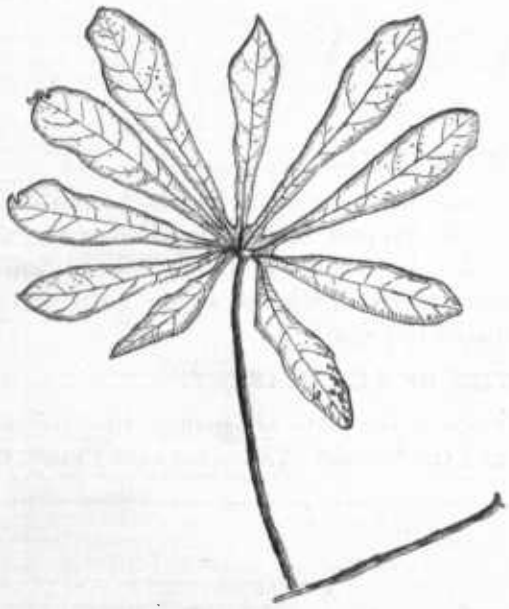

FIG. 2.—Leaf of the variety *multifida*.

The plant grows as a bushy shrub from 4 to 10 feet in height, the branches forking repeatedly, those from which the leaves have fallen being quite rough, with transverse wrinkles above and below each bud. The leaves are on slender petioles, which are from 6 to 12 inches in length, the blade being deeply palmately divided into from 3 to 11 divisions, which are oblanceolate in form, from three-fourths to 1½ inches in width by 5 to 10 inches in length, light green in color, and very smooth, though the divisions vary greatly in size, number, and shape. Leaves having from 3 to 11 divisions are sometimes found on a single plant, though 5 or 7 are the numbers more commonly seen.

FIG. 3.—A leaf of the variety *genuina*.

LEAVES, FLOWERS, AND ROOTS.

Fig. 1 shows a few of the variations found in a single field where the usual number of leaf divisions was 7, while fig. 2 shows still other forms from a field in which the leaves usually showed 9 divisions and

which apparently represents the variety *multifida*. Another form is shown in fig. 3, in which the divisions are very narrow and were almost uniformly 9 in the field from which it was taken, and this represents the variety *genuina* of some authors. Fig. 4 represents the form most common in this country, and is that which is known as the variety *aipi*. The flowers are in loose, spreading clusters near the ends of the branch, being about three-eighths of an inch in diameter when open and varying from greenish purple to light greenish yellow in color. The seeds, which are nearly as large as those of the castor bean, are borne in globular pods, ranging from three-fourths to 1 inch in diameter and are more or less completely encircled with narrow wings or ridges, each pod containing 3 seeds, usually mottled with light and dark gray. The roots (fig. 5), which are the only valuable portions of the plant, grow in clusters from one end of the seed canes planted, single roots being from 1½ to 2½ inches in diameter and from 1½ to 4 or more feet in length, and usually are red or brown in color, though sometimes nearly white. Clusters of roots ordinarily weigh from 5 to 10 pounds, though they often reach from 20 to 30 pounds each. The two shown in fig. 5 together weighed 29½ pounds.

FIG. 4.—The common form variety *aipi*.

FIG. 5.—Some two-year-old cassava roots.

BITTER CASSAVA.

The "bitter" cassava is the form more commonly grown in the Tropics, as it produces a greater yield of roots there than can be secured from the "sweet" varieties, though it requires a much longer season for its

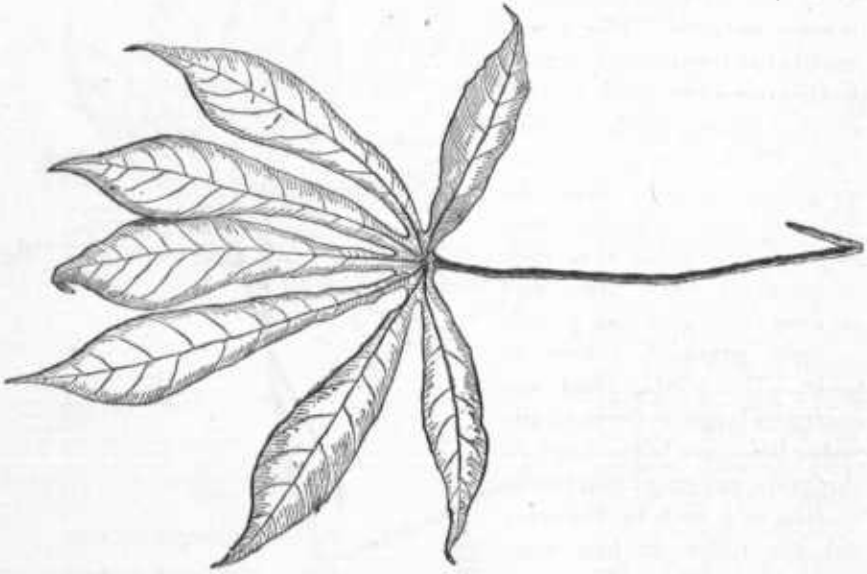

FIG. 6.—Leaf of bitter cassava.

growth, some sorts not reaching full maturity under six years.

Leaves from plants of this form are shown in fig. 6 and differ so little from those of some varieties of the sweet cassava that it is difficult to distinguish them, even when they are growing in the same field.

Poisonous Constituent and its Elimination.—There are a dozen or more varieties of the bitter cassava grown in Brazil, differing principally in color of stems and roots and in time of maturity. All of these varieties contain a considerable amount of the active poison known as prussic acid, the same poison to which the occasional "sorghum poisoning" in this country is now attributed. Fortunately, however, this poison is very volatile and is entirely dissipated by moderate heating or by exposure for a few hours to the direct rays of the sun, so that when the roots have been cooked they may be eaten with perfect safety. It is from this root that nearly all tapioca is made, and it also forms the principal starch or bread-substitute food in many tropical countries.

SWEET CASSAVA.

So far as is known, the sweet or nonpoisonous form is the only one found in the United States. One of the Florida starch factories imported a quantity of the bitter sort in 1898, but it matured so much later and was so much less productive than the sweet variety that it

was soon discarded. A few other importations have been made, but the plants have required such a long season for maturing that they have been unsatisfactory.

No case of poisoning from the eating or feeding of cassava has ever been known in this country, and there is little probability that the poisonous element in the bitter cassava of the Tropics would be developed in plants grown in any part of the United States where the growing season is so much shorter and the climate so much cooler. It is a well-known fact that many plants which in their natural condition develop certain qualities to a marked extent fail to show those qualities when grown under different conditions. Instances of fatal poisoning from eating the roots of the wild parsnip are often reported, though the removal of the plant from uncultivated fields to rich and highly cultivated gardens renders it a harmless and nutritious food plant. The transfer of the poisonous form of cassava from its tropical home to the very different climate of the United States and also the selection of varieties which mature their growth in a much shorter time seem to have effected a similar change, and so to have developed the nonpoisonous sweet variety. Only 3 or 4 varieties of the sweet cassava are now known in this country, though from 40 to 50 are cultivated in Brazil.

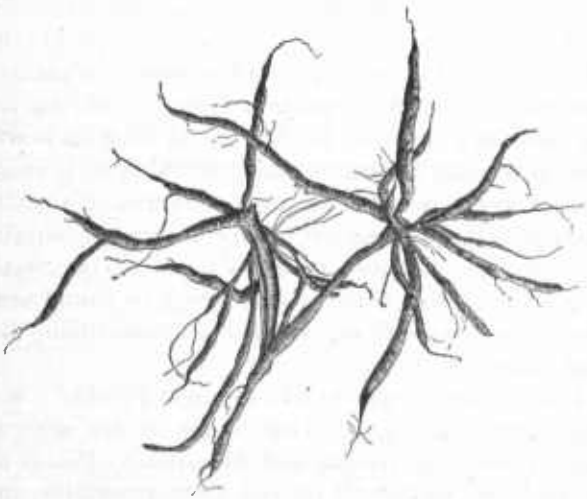

FIG. 7.—Roots of cassava at end of one season.

HISTORICAL REVIEW.

There are no definite records which indicate when cassava was first cultivated in the United States. It was common in many parts of Florida more than forty years ago, and during the civil war was used quite commonly for the production of starch in small quantities for domestic uses. Cassava starch, however, does not appear to have become an article of trade until about 1898.

USE IN FEEDING STOCK.

The value of cassava for feeding stock attracted no special attention until within a few years, and little regular feeding was done with it

until about 1895. Prior to that time it was used occasionally for feeding poultry during the winter and a little was sometimes used in fattening hogs, though it was rarely grown for that purpose. The freezes of 1894–95, which destroyed so large a part of the Florida orange groves, forced the planters to undertake new lines of work and to consider the cultivation of new crops, and, very wisely, increased attention was given to the raising of live stock. Corn, oats, and other grains do not produce so well on the light, sandy soil common to Florida as on heavier soils farther north, and some less expensive substitute for them had to be found before stock growing could be made profitable. Cassava, being already fairly well known as a garden crop, was planted in field areas and soon proved itself an important factor in solving the problem of producing meat at a low cost for feed. As soon as it was learned how easily the crop could be grown and how valuable it could be made in feeding, the acreage devoted to cassava increased rapidly until at the present time it is larger than ever before. Fields containing from 5 to 10 acres each are common in many parts of the State, while fields containing from 50 to 100 acres each are now found near the factories which have recently been erected for manufacturing the starch on a commercial scale.

At about the same time cassava began to win favor in Florida it was also planted in various places along the Gulf coast as far west as Louisiana, and also as far north as Atlanta and Memphis. When on suitable soil near the Gulf of Mexico, it proved quite profitable and soon established itself as a permanent crop, but farther north it proved less satisfactory and its cultivation there is not increasing.

LIMIT BY FROST OF REGION FOR GROWING.

Cassava is a native of the Tropics; its growth is stopped by a light frost or even by continued cool weather, and it can not be cultivated profitably except in localities having a warm climate free from frost for at least eight months, while ten or eleven months of freedom from cold will enable it to produce a much heavier yield. Such a climate is found only in the extreme southern part of the United States, including practically the whole of Florida, and also a narrow strip of country, probably less than 100 miles in width, along the Gulf coast from Florida westward to Texas. Many attempts have been made to grow it farther north, but the seasons have invariably proved too short for a satisfactory growth and the fall frosts have killed the tops of the plants before the roots were well grown and while they were so watery and immature as to be greatly inferior in feeding value to those grown in a warmer climate and during a longer season.

Even in tropical countries the coast regions seem much more favorable for its best growth than are those at any great distance from the ocean, and it is not a plant which promises to be profitable for

cultivation except in a limited section of this country, its range being about the same as that of the velvet bean. (See Fig. 8.)

SOIL AND MOISTURE REQUIREMENTS.

The best soil for growing cassava is a light, rich, sandy loam, and many growers prefer that such a soil should be underlaid by a hardpan, which will prevent the roots from going too deep into the ground. The soil should be dry rather than wet, and fair yields can be secured from soil too dry for corn and most other crops. It is emphatically a drought-resistant plant, a characteristic which makes it specially valuable for sandy soils, which become very dry even when drought is of only a few weeks' duration. While abundant moisture is needed to

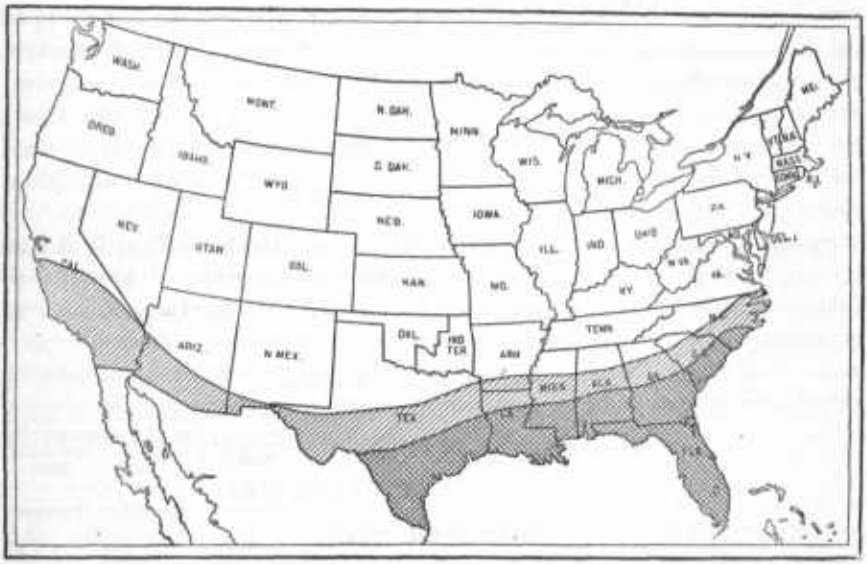

FIG. 8.—Map showing region where climatic conditions are favorable to cassava growing: Heavily shaded area shows where cassava is now grown successfully; lighter shaded area indicates probable limit of successful cultivation.

induce the seed canes to sprout, after the young plants become well established they will bear long-continued and extreme drought with little injury, and the crop never proves a total failure for want of rain.

While the soil should be light and dry, it should be as rich as for any other crop. It is useless to expect a heavy crop of any kind from a barren soil, and cassava is no exception to the rule. If the soil on which it is to be planted is not already rich, it must be made so before the crop can be made profitable. As the roots are long and spreading, it saves considerable labor in digging if they can be kept near the surface of the ground, so an underlying hardpan is not as objectionable as when taprooted plants, or plants which must draw an abundant supply of moisture from the subsoil, are to be grown. In lifting the

roots out of the ground in digging it makes a great difference whether they are covered with 6 or 16 inches of soil.

A swampy, seepy, or wet soil should be avoided, as such soils will produce only a sickly growth of plants, and the yield of roots will be less than on a drier soil. Heavy, black soils are also objectionable, as they produce only a small yield, and the compactness of the soil makes the roots hard to dig. Soils which are excessively rich in humus should also be avoided, as they produce an excessive growth of tops with small and watery roots. Heavy, barren clay soils are equally unfitted to the crop, as they produce small yields, which are difficult to handle.

In short, the soils best suited to the growth of cassava are those which are best for a crop of sweet potatoes, and, where the warm season is sufficiently long, any soil which will produce a good yield of sweet potatoes will produce a correspondingly good yield of cassava, if the other climatic conditions are suitable.

FERTILIZERS.

CONSTITUENTS OF CASSAVA.

Cassava is one of the crops least exhausting to the soil, as is shown by the following analysis made under the direction of Dr. H. W. Wiley, Chief of the Bureau of Chemistry, U. S. Department of Agriculture:

Chemical composition of cassava.

Constituents.	Factory waste.	Stalks from Orlando, Fla.	Stalks from Wortham, Miss.
	Per cent.	*Per cent.*	*Per cent.*
Moisture in fresh sample	11.70	.....	61.20
Dry matter in fresh sample	88.30	.....	38.80
Potash in dry substance	.16	0.69	1
Phosphoric acid in dry substance	.10	.87	.36
Ash in dry substance	2.94	3.70	3.61
Nitrogen as ammonia in dry substance	.43	.....	.69

KIND AND QUANTITY OF FERTILIZER.

The composition of any commercial fertilizer which is to be used should be varied with the character of the soil and its previous treatment. The best preparatory crop is velvet beans or cowpeas, either of which will leave the soil in excellent mechanical condition and will furnish all the nitrogen needed by the cassava. On such soils potash and phosphoric acid are the only chemicals needed, and both should be supplied in moderate quantities. A common mixture for a fertilizer is made by using 200 pounds of kainit or 50 pounds of muriate of potash and 300 pounds of acid phosphate, less of the phosphate being used on limestone lands and more on light, sandy soils. From 200 to 400

pounds of this mixture are used per acre. Some growers prefer ground bone in the place of acid phosphate. If the crop does not follow velvet beans or cowpeas, nitrogen should be added to the mixture, and nitrogen is secured most economically in cotton-seed meal at the rate of from 200 to 400 pounds per acre. In a few cases nitrate of soda has been used with profitable results soon after the plants came up. While the fertilizing should be liberal, it should not be excessive, as an excess of fertilizer causes a large growth of stalks without a corresponding increase in the yield of roots, and many growers claim that too heavy fertilizing actually decreases the yield.

EFFECTIVENESS OF FERTILIZERS.

In discussing the results of fertilizer tests made at the Florida experiment station Dr. Stockbridge says, in Bulletin No. 49 of that station, that while the check plots which received no fertilizer yielded only 7,420 pounds of roots per acre, the average yield of the fertilized plots was 12,979 pounds per acre, and that "these different results lead to the natural conclusion that the most economical fertilizer for soils like ours at the station should furnish the crop with the equivalent of 62½ pounds of acid phosphate, 150 pounds of cotton-seed meal, and 37½ pounds of muriate of potash, making a total application of 250 pounds, having a percentage composition of approximately 2.6 per cent phosphoric acid, 3 per cent nitrogen, and 5 per cent potash."

These results agree very closely with the general experience of planters, except that when the preceding crop was a legume the cotton-seed meal may safely be omitted, while on very poor soils all the ingredients should be somewhat increased.

PREPARATION OF THE GROUND.

CROP ROTATION.

The best crops to precede cassava and to put the soil in good condition for its growth are velvet beans or cowpeas. In the region where cassava can be grown the velvet bean will make a rank growth and mature its seed, and so is generally preferred to the cowpea, though the latter has the advantage of making its growth in a shorter time and so is commonly used where the land has been occupied with oats or some other crop during the spring and early summer. As these legumes are very rich in protein, they make the very best of material for forming a balanced ration when fed in connection with the cassava, which is distinctively a carbonaceous feed. This fact has become well recognized by those who have used cassava for feeding, and on nearly all stock farms one or both the legumes mentioned are grown so extensively that it is usually a simple matter to arrange the fields so that cassava shall follow one of them.

PLOWING AND MARKING, AND APPLICATION OF FERTILIZER.

The ground is prepared for planting by plowing it broadcast[a] as for any ordinary crop, the plowing being done only a short time before planting and followed by a harrowing to smooth off rough places. The marking in one direction may be done with an ordinary corn marker marking three or four rows at once, or by using a small plow. The cross marking, however, should always be done with a plow and the rows opened so deep that the seed canes can be easily covered. If fertilizer is to be used it should be applied at this time, and the work may be done by running an ordinary fertilizer distributer along the rows or by scattering it in the furrows by hand and then following with a bull-tongue plow to mix it with the soil. When well-rotted stable manure or cotton-seed meal is used, it may be dropped at the intersections of the rows where the planting is to be done, but when strong commercial fertilizers like muriate of potash and acid phosphate are used, they must be well mixed with the soil, as they are almost sure to burn and injure the seed canes with which they may come in contact.

CASSAVA IN ORCHARDS.

It is a common practice to plant cassava in orchards, and in such cases, of course, rows can be made only in one direction, and as the welfare of the trees is the most important object, the plowing should be as deep as possible without injury to the tree roots, and the fertilizing should be liberal.

PLANTING THE CROP.

TIME OF PLANTING.

Planting is done as early in the spring as is safe, not later than February in middle and southern Florida, and not later than the first of April in any part of the cassava-growing region. Some growers prefer planting in December or January, and that practice is often very successful, but should never be followed where the soil is liable to remain water soaked for any great length of time during the winter. On well-drained, light, sandy soils this very early planting is often the better method, as it enables the seed canes to take advantage of every warm day to form roots and so be ready for active growth a little earlier in the spring, but it is not a safe method on any but the driest of soils.

CUTTINGS USED AS SEED.

The crop is not grown from seeds but from the canes or stalks grown the previous season and kept through the winter much as sugar cane

[a] "Broadcast" is a term used to distinguish ordinary plowing from a kind of plowing peculiar to cotton raising in the South.

is preserved for planting, the details of storing and keeping them being given on page 17. When the field is ready for planting the seed canes are cut in pieces from 4 to 6 inches in length. Some planters insist on having each piece not less than 6 inches long and prefer 7 or 8 inches, claiming that such large joints produce a quicker growth and more vigorous plants than can be secured from smaller pieces, and also claiming that there is less danger of their drying out if a severe drought occurs immediately after planting. The majority, however, use pieces from three to four inches in length and claim that such a size is ample, and that a better stand can be secured by planting two 3-inch pieces than one 6-inch piece in a hill.

CONDITION OF SEED CANES.

Whatever may be the size of the pieces planted, care should be taken to see that they are alive and in good condition. One can usually tell the difference between live and dead seed canes by their general appearance, the live canes being plump, with fresh-looking bark, sound pith, and full eyes, while the dead canes usually show their condition by their shrunken appearance, bleached or darkened color, discolored or dried pith, and shrunken eyes. In nearly or quite all cases if the skin near an eye on a live cane is cut with the thumb nail, fresh and slightly milky juice will be seen in the wound, while a similar puncture in a dead cane will remain dry or show only watery or discolored juice. Of course it is worse than useless to plant dead seed canes; so it always pays to take all due care to see that only live canes are used. One extensive grower says: "If the seed canes are surely good, use pieces 6 inches long; if they are questionable or slender, use 8-inch pieces; while if they are doubtful, throw them away." It is not uncommon to see fields with not more than two-thirds or three-fourths of a full stand, and the failure to secure a full stand is almost invariably caused by the use of poor canes. Whether the pieces of cane planted are 3, 4, or 8 inches in length makes no difference if they are dead or so weakened that they fail to sprout, while sound canes 4 inches in length seldom fail to grow well when planted in favorable soil. One piece of sound cane is all that should be planted in a hill, and canes of doubtful vitality are seldom worth having.

CUTTING THE SEED CANES.

The seed canes are usually kept through the winter in whatever lengths they happen to come from the field, and they are not cut into smaller pieces until they are wanted for planting. This cutting should be done with some care to prevent the ends of the pieces from being crushed or splintered, thus destroying a portion of the eyes and making the whole piece much more liable to decay. The cutting may be done with any implement which will make a clean cut. An ax or a hatchet

is almost sure to leave the ends somewhat broken, and the canes are too large and woody to be cut easily even with very heavy pruning shears. A machete or a heavy cane knife is often used and will do fairly good work. The most convenient implement and the one in most common use is a common carpenter's saw with rather coarse teeth and set a little wider than usual. The saw is fastened on its back to a heavy block or a bench, with the handle away from the workman. In using it the workman grasps a cane with both hands and a single push along the saw edge is sufficient to cut all except a few of the largest and heaviest canes, which may need a second stroke. With the saw on a bench of convenient height the canes can be cut very rapidly, the length of each piece can be made to suit the size and condition of the cane, the ends of the pieces are left smooth and sound, and there is almost no waste. No other method of cutting the canes has been found so easy, quick, and satisfactory.

USE OF SPROUTED CANES.

Some growers think it better to sprout the seed canes before planting. This is done by cutting them into pieces of the proper length and then bedding them like sweet potatoes; the live canes will make sprouts in a few days and may then be planted with almost a certainty of securing a full stand. This method is of special advantage when it is desirable to plant at the very earliest possible date, and when the seed canes are of doubtful vitality. A little additional care must be taken to avoid breaking off the sprouts when such canes are used, but the better stand secured will usually more than pay for the labor.

DROPPING AND COVERING THE CANES.

The pieces of seed cane are dropped, one at each cross row, and covered with a plow or hoe as Irish potatoes are covered, the covering being from 2 to 4 inches in depth, the deeper covering being given on the lighter soil.

CULTIVATION.

Cassava requires no special cultivation beyond that needed to keep the ground free from weeds and the surface loose and friable. The first cultivation is often given with a smoothing harrow before the young sprouts reach the surface of the ground. Some growers give this cultivation by plowing deeply between the rows and cleaning the remainder of the surface with a hoe, while others prefer a five-toothed cultivator for the work. It really makes little difference what implement is used in this first cultivation provided it is one which will kill all the young weeds, and little is gained by deep plowing between the rows except on soils which are too heavy to be well suited to the growth of the crop. All the later cultivations, however, must be as shallow as

possible, for the cassava roots lie very near the surface of the ground. Some growers use a single section of a smoothing harrow for all the later cultivations, and find it very satisfactory when used with sufficient frequency to prevent any grass or weeds from becoming firmly rooted. Others prefer a 24-inch sweep run very shallow, while still others prefer a five-toothed cultivator. Whatever implement may be preferred should be used so frequently that the surface of the ground will at all times be covered with a dust mulch to prevent the sandy soil from becoming too dry, and the cultivation should be continued until the plants become of sufficient size to shade the ground. Two cultivations are often sufficient on land which is fairly free from weeds, as the cassava plants soon form a dense shade.

The surface of the ground should always be kept as nearly level and smooth as possible, and no hilling up should be given, as many of the roots reach nearly or quite across the spaces between the rows. Hoeing will not be needed when the ground is not filled with weed seeds and when the first cultivation is given with a smoothing harrow, but the rows should be kept free from weeds, even if they have to be hoed twice. Ordinarily the crop requires about the same amount of cultivation which is given to cotton, and there is little difference between the two in the expense per acre for making the crop.

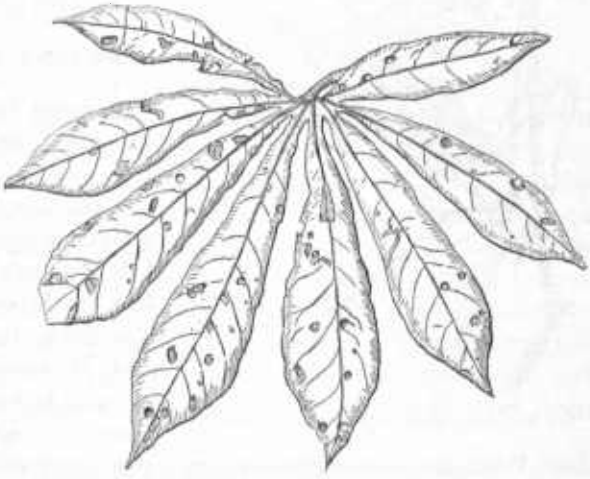

FIG. 9.—Spot disease (*Cercospora henningsii*).

DISEASES.

Two diseases caused by parasitic fungi have been observed. One of these, known as the "spot disease," shows its presence by numerous dead spots on the leaves, the spots being usually about one-fourth of an inch in diameter.

Leaves affected by this disease are shown in fig. 9. It is caused by a minute fungus known as *Cercospora henningsii* Allesch. As it makes its appearance late in the season, and as it usually attacks only leaves which are nearly matured, it does little harm and is not so severe as to make any preventive treatment necessary.

The other disease, known as "Frenching," or "little plants," is caused by another fungus, *Glœosporium manihot* Earle, and its effects are shown in fig. 10.

It attacks the growing branches near the ends, soon killing them at that point and spreading downward somewhat slowly. This disease has been found in about one-half of the fields examined during the past season, and has caused somewhat serious losses in a few cases, though it is seldom so prevalent as to attract special attention. While it is difficult to treat the disease in an economical and effective manner, it may be almost wholly prevented by planting seed canes from uninfected fields only.

FIG. 10.—Frenching (*Glœosporium manihot*).

HARVESTING THE CROP.

SAVING THE SEED CANES.

Dangers to be avoided.—One of the most difficult things in growing cassava is saving the seed canes for planting. They are killed by a frost which is severe enough to kill tomato vines. If stored when too fresh, or kept too dry, they are liable to suffer from dry rot; and if covered too closely, or allowed to become thoroughly wet, they are almost sure to decay. Still there are many growers who are successful in saving the canes year after year, and a little experience shows what is really necessary as well as what must be avoided.

Time of cutting.—Only well-matured canes can be kept through the winter, and these should be cut as late in the season as is possible, since the roots are then making their best growth and cease to grow as soon as the canes are cut. Still, the cutting must not be delayed too long, as a moderate frost will kill them. In Florida a large part of the 1901 canes were killed by a heavy frost on November 17, nearly a month earlier than such frosts usually occur in that region. As a result of this a large part of the canes grown in that region in 1902 had been put away as early as November 15. Many growers stored away a part

of their canes early in November and allowed the remainder to grow until December, when, as there had been no frost, more were stored and in better condition than those cut earlier, as the roots had made a largely increased growth. When there is a fair stand of plants the canes from 1 acre will be sufficient to plant from 4 to 6 acres the following season; so when it is not desired to increase the acreage rapidly, the safer plan is to store one lot before there is any danger from frost, and another lot later in the season when the roots are gathered, provided the second lot is then in better condition than the first. When the canes are in good condition and the grower can save them without serious loss, they are at present a profitable part of the crop, as the total acreage is being increased yearly and there is always a good demand for seed canes at planting time. The acreage of cassava in Florida in 1902 was smaller than in 1901 by fully 25 per cent, and the reason was the shortage of seed canes. If there had been a supply, the acreage would have been increased 25 per cent over that of 1901.

Portion of stem to be saved.—The plants usually grow with a single stem from 1 to 2 feet in height, and then divide into three branches. These branches make a growth about equaling that of the main stem and then divide into three, and in time these divisions may be again divided and subdivided into threes. The main stem and the three branches below the second forking will mature sufficiently to be saved, but the upper branches should usually be discarded. When the canes are cut, which should be done about 6 inches above the surface of the ground, the immature ends and leaves are cut off and left to decay in the field, as they would be liable to heat and cause decay. Two of the three branches on the part to be saved are cut from the main stem, so that they can be stored in less space. This cutting and trimming can be done very rapidly with a machete or a cane knife, and it is better to store the canes as soon as they are cut to prevent them from becoming too dry.

Methods of storing.—There are several methods of storing the canes which have been found very satisfactory, though they differ somewhat widely from one another. Some growers trench them like sugar cane, opening a deep furrow, laying the canes in lengthwise five and six layers deep, and then covering with earth. This method is fairly successful when the trenching is done on ground which is high and dry, and ditches reaching well below the bottom of the trench are left on each side of the finished covering, but it requires considerable labor as well as a wide space.

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Less space is required by selecting a dry spot for the bedding out and making the bottom of the bed a succession of sloping surfaces, as shown in fig. 11. The sloped surfaces *bc* are about the length of the canes to be stored, usually from 2 to 3 feet, while the nearly perpendicular surfaces *ba* are from 4 to 6 inches in height. Such a bed may be of any convenient width and length. In storing the canes they are placed two or three layers deep on the sloping surfaces, care being taken to push the butts firmly against the perpendicular surface *ba* to prevent them from becoming dry. The beds are then covered with 3 or 4 inches of straw and then with about 2 inches of earth, which is increased to 6 inches when the weather becomes cold.

A common method in central Florida is to dig a ditch about 18 inches in depth, from 3 to 4 feet wide, and as long as may be needed. The canes are set on end in this ditch, packed as closely as possible, and then covered with straw or litter, which is held in place with a little earth. The top covering is left rather thin until cold weather, when more earth is added.

A similar method is followed by the managers of the starch factory

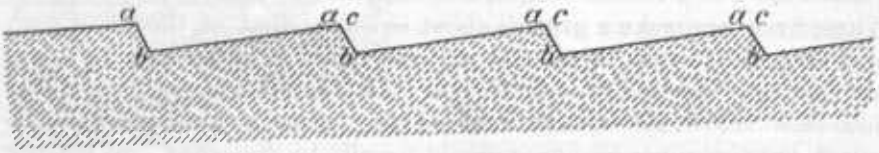

FIG. 11.—Method of preparing bed for keeping seed stems over winter.

at Lake Mary, Fla., excepting that they make the ditches 6 feet wide, 12 feet long, and 6 inches in depth, the limit on length being simply a matter of convenience. A covering of pine straw is put on as soon as a bed is filled, and a day or two later this is covered with earth. The straw covering used in the two methods last mentioned should not be too thick when the canes are first bedded, as it is liable to induce heating and dry rot. In fact, if this covering is thick enough to prevent the later covering of earth from falling through between the canes, it is all that is needed. As soon as the beds are filled and covered they should be protected by a roof which will exclude rain.

Still another method is to build a permanent house, similar to a potato house, with sides about 3 feet in height. The canes are stood on end to fill the house, their tops being well covered with straw and the sides of the house well banked with earth.

Essential points in storing.—Numberless variations of each of these methods are practiced, but all agree in a few essential particulars, namely: The canes must be well matured when stored; they must not be stored while wet; after they are packed in the beds they must be covered lightly at first to permit the escape of surplus moisture; they

must be covered more deeply later in the season to exclude cold, and the covering must always be one which will not permit rain to soak through into the bed. Dry rot and decay are the troubles most to be feared; the former coming from storing immature canes and from heating, while the latter usually follows the presence of too much moisture.

DIGGING THE ROOTS.

Time of digging.—Digging usually begins about the 1st of November and continues until about the 1st of February, where the roots are grown for the manufacture of starch. As a portion of the starch is transformed into glucose at the beginning of the spring growth, the roots become less valuable to the factories with the approach of warm weather, though worth nearly or quite as much for feeding purposes. Digging may begin earlier, or may continue through the entire year where used for feeding stock, though usually the roots are not used between May and October. If the entire crop is not wanted for use during the winter following its growth, a part of it may be left in the ground for another season, as the roots will continue to grow several years if not disturbed. Roots which have grown two or more seasons often reach an enormous size, sometimes as much as 8 feet in length and forming clusters weighing more than 100 pounds; but they become more hard and woody than at the end of the first season, and so are not as good for the manufacture of starch or for feeding as those which have grown only one season. When it is known beforehand that a part of the crop is to be kept until the second season, it is better to dig alternate rows, so that the plants remaining will be less crowded.

Means of removing from the ground.—As the roots are of considerable size, often from 3 to 4 feet in length by 2 or 3 inches in diameter, and as they grow in clusters of from 4 to 8 on each stalk, a single cluster often weighing from 20 to 30 pounds, the digging can not be done with a plow, as sweet potatoes are dug, but must be done by hand. The original section of seed cane which was planted does not decay when growth begins, but continues to live and grow through the entire season, the new stalk usually growing from one end and the cluster of roots from the other. The piece of seed cane which was planted thus becomes what is called the "union" between the stalk and roots of the new plant. When the stalks are cut, either for seed canes or to clear the land for digging, a stub 5 or 6 inches high is left to show the position of the root and to furnish a hold for pulling them from the ground.

Implements used in digging.—Various tools are used in digging, and sometimes, especially when the soil is very light and the root growth is small, the work is done by simply grasping the stub with the hands and pulling the roots, without the use of any tools. This

method answers very well on light soil and when only a few roots are gathered daily, but where the soil is of fair quality, and where any great amount is to be gathered, some simple tool is of great assistance. Some growers use a grubbing hoe, pushing the blade into the ground under the union and then alternately pulling and prying until the roots are so loosened that they can be lifted out. Others use a cant hook, such as is used in handling logs, pushing the hook under the union and then lifting the cluster of roots from the soil. Still others use pinchers much like large blacksmith pinchers, but with the end of each handle turned into a ring for a hand hold. The user grasps the stub with the jaws of the pinchers and then pulls and shakes the root cluster until it is loose from the soil.

Where considerable quantities of the root are to be dug, an implement called a "lifter" is very commonly used. This lifter is simply a straight piece of wood about 8 feet in length and 2 inches in diameter, with a V-shaped hook about 2 feet from one end. The hook is of iron or steel, and can be made by any blacksmith from an old file or a piece of a wagon spring by bending it edgewise, so as to make the opening from 5 to 6 inches in length and about 2 inches in width at the open end. Two holes are punched through one arm, so that it can be bolted to the wooden handle, and the inside edges are beveled from below, so as to make them sharp. This hook is bolted to the handle in such a position that the inner edge of one arm is about an eighth of an inch outside the side of the handle, and usually on the right-hand side as a matter of convenience. The opening of the hook is toward the long end of the handle, and the lifter is used by catching the hook over the stub and then lifting and shaking the roots until they are free from the soil. The short end of the lifter, which rests on the ground, is sometimes finished off by bolting to it an old spade blade or some other piece of iron of a similar shape to give a broader rest, which will prevent the end of the lifter from burying itself too deeply in the soil, and which is also very convenient for chopping off weeds or other obstructions and for a little digging, which is sometimes needed. The arms of the hook should be from 1½ to 2 inches in width, and the handle should have a little additional size where the bolts pass through, as both hook and handle are under a considerable strain when lifting heavy roots from a compact soil. The cost for digging will depend on the yield, but will not be far from $1 per ton.

STORING THE ROOTS.

In order to preserve them for any length of time after they are removed from the ground the roots must be kept warm and dry. Usually they begin to blacken and decay within three or four days after they are dug, so the common practice is to dig from day to day as they are needed, or at most for not more than a week in advance. Roots

may often be kept for weeks, or even two or three months, in a warm room, but when exposed to air of the ordinary winter temperature and dampness they soon show black streaks, quickly followed by souring and a soft decay which renders them wholly unfit for any use. Roots which have become sonred make a very unwholesome food and should never be given to any kind of stock.

With just the right treatment, however, the roots may be kept in good condition for two months or longer. It is true that a majority of those who have tried storing them have made more or less complete failures, but a few who have stored away the roots about the middle of November have kept them in perfect condition until January. Those who have been most successful in keeping them have treated them much as they would sweet potatoes, digging them in a dry time and taking great care that they should not be bruised or twisted in handling, and some think it necessary that they should remain attached to the "union." In storing they should not be put in large piles, the work should be done only on warm days, and the first covering must be only of straw or litter, which will not prevent the evaporation of moisture. More covering must be added whenever necessary to protect from cold, and the piles must always be thoroughly protected from rain. A root which is always warm and dry will keep for a long time, while one which is cold or wet will decay very quickly. When kept in a warm room, exposed to the air, they will remain sound for a long time, but become somewhat dried and shriveled, and so are less valuable for feeding, though uninjured for making starch.

YIELD AND PROFIT.

PRODUCTION BY THE ACRE.

The yield of cassava is as variable as that of other cultivated crops, its amount depending principally on the vitality of the seed canes planted and the quality of the soil. The character of the season, whether wet or dry, seems to have less influence than its length. On very light, worn, sandy soils, where no fertilizers are used, the yield may not be more than 2 or 2½ tons per acre, while on reasonably good soils which have been given a moderate amount of fertilizer, or on which a crop of velvet beans or cowpeas was grown the previous season, a yield of from 5 to 7 tons may be expected. Some of the best fields, where the soil is just right and a full stand of plants is secured, make from 10 to 15 tons per acre, but such yields are unusual. Captain Wilmoth, of Harrison County, Miss., gathered 9 tons from 1 acre which had been fertilized with 200 pounds of bone meal. Mr. Bell, of Baldwin County, Ala., harvested a crop of 25 tons from 2 acres without the use of any fertilizer, but his soil was unusually good, and he was fortunate in securing good seed canes for planting. Yields of

from 20 to 30 and even 40 tons per acre are often reported, but it is very doubtful if as much as 20 tons has ever been gathered from 1 acre of land. Such reports have usually been based upon the weight of a few roots from which the yield of an acre has been estimated.

UNRELIABLE ESTIMATES.

While this bulletin was in preparation one Florida newspaper published a description of one root weighing 29½ pounds, and stated that the yield of the field would be 39½ tons per acre. Roots weighing 40 pounds are occasionally found, and by the same method of calculating the yield, 1 acre would produce 54 tons. Roots two years old sometimes weigh as much as 150 pounds each, which is at the rate of 204 tons per acre. Of course all such estimates are absurd, and any estimate which is not based on the actual weighing of the crop from at least one-tenth of an acre is wholly unreliable. The number of plants missing on an acre is always large, and usually much larger than will be estimated without a count over a considerable area, and it is impossible to select "average" plants. One grower reports that he endeavored to select "average" plants, and from their weight he estimated his yield as being a little over 15 tons; but when the roots from the entire field, covering several acres, were dug and weighed, the actual yield was found to be only about 6½ tons per acre.

EFFECT OF POOR STAND OF PLANTS.

A planter near Pensacola, Fla., who has grown the crop quite largely for three years, says: "Our yield has been from 3 to 9 pounds per hill (2,700 hills to the acre), but on account of a poor stand from various causes our average per acre so far has been about 2½ tons."

In a large number of fields examined during the past season it was very rare to find one in which at least one-fourth of the hills were not missing, one-third were often wanting, and many rows which were counted showed that fully one-half the seed canes had failed to grow. It is this common failure to secure a full stand which is responsible for a heavy diminution of the yield which might have been secured by greater care in the selection of seed canes for planting. Those growers who secure the maximum yields of from 10 to 12 tons per acre are those who are the most careful to see that every piece of cane which is planted is in a condition to grow, and who discard all which are even doubtful. An acre of ground should have 2,722 hills when the planting is done at the usual distance of 4 by 4 feet, but it is very rare that as many as 2,500 plants are secured, while from 1,500 to 2,000 is a number more often found. With sufficient care in the selection of seed canes so as to secure a full stand of vigorous plants, the average yield would be increased fully one-fourth. No one point in making the crop is of greater importance than this.

Latitude seems to have little influence on yield, as fields in

Mississippi and Alabama produce fully as much as do those in southern Florida.

CASSAVA AS A STOCK FEED.

Fully 95 per cent of the cassava now grown in this country is fed to live stock, the amount used by the starch factories being an insignificant part of the crop. It is fed to horses, mules, milch cows, fattening cattle, hogs, and poultry. All kinds of stock eat it with relish and thrive upon it much better than when confined to any dry feed. Being so highly carbonaceous in its composition, it is commonly fed in combination with bran, shorts, cotton-seed meal, or other nitrogenous grain feed and, when judiciously used, it is one of the most inexpensive feeds which can be grown. It is less watery than either sweet or Irish potatoes or turnips, while its yield is fully twice as great. One hundred bushels of sweet potatoes per acre is a fair crop, but it weighs only 3 tons, while from 5 to 6 tons of cassava could be grown on the same ground with less expense. As the roots are always fed in a fresh condition, they furnish an excellent substitute for winter pasture, and so do much to keep animals in good condition through the season of dry feed. Where the crop can be grown successfully, it can be made to take the place of a silo, as the feed is much more nutritious than silage, and can be used economically when one has too few animals to make a silo profitable.

In nearly all cases the roots are fed as fast as they are dug, as they never fail to keep in good condition so long as they are left undisturbed in the ground where they grew. The roots are so smooth that if they are dug when the soil is dry they need no washing or cleaning before being fed, and no special preparation beyond cutting them into small pieces before feeding them to cattle.

FEEDING VALUE AS SHOWN BY ANALYSIS.

According to recent analyses made in the Bureau of Chemistry of the Department of Agriculture, the chemical composition of cassava roots is as follows:

Composition of dry roots of cassava.

Constituents.	From Orlando, Fla.	From Lake Mary, Fla.	From Muscogee, Ala.	From Worthham, Miss.	Average.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	5.47	5.11	7.05	5.39	5.76
Ether extract	.37	.50	.49	.26	.42
Crude fiber	4.05	6.58	6.06	3.76	5.08
Pentosan	3.09	2.93	2.43	2.06	2.63
Starch	57.60	67.20	62.19	70.13	64.28
Protein	3.42	3.16	2.37	2.98	2.98
Ash	1.47	1.56	3.04	1.75	1.96
Undetermined (sugars, soluble cellulose, etc.)	24.53	13.01	16.37	13.67	16.89

The proportion of water in the fresh roots is somewhat larger early in the season than in winter, but averages about 66 per cent. With that amount of water the analysis of fresh roots, based on the analysis of dry roots as given above would be approximately as follows:

Moisture	66.00
Ash	.71
Protein	1.07
Crude fiber	1.83
Nitrogen—free extract	30.24
Ether extract	.15

This makes a feed in which the carbohydrates are largely in excess and which has a nutritive ratio of 1:28.5 instead of 1:7, which is about the proportion preferred by the most successful feeders. Fortunately, however, velvet beans or cowpeas are the cheapest hay feeds which can be grown in the cassava-growing regions, and cotton-seed meal is the cheapest grain feed which can be purchased, and all these feeds are unusually rich in protein and deficient in carbohydrates; so that a combination of cassava with either of these makes a perfectly balanced ration which is easily varied to meet the needs of growing animals, of milch cows, or of stock which is being fattened.

FEEDING TO CATTLE.

Effect on milk.—Cassava is fed to cattle more than to any other kind of live stock, and is valued especially for milch cows and for fattening. It is fully equal to silage in stimulating a flow of milk, to which it gives a rich color but no distinct flavor such as comes from giving silage, turnips, and some other feeds when used too freely. A few feeders have stated that, when fed too heavily, it gave the milk a slight reddish tinge, though those dairymen who have used it most largely state that they have never seen any such discoloration of the milk, and that its only coloring effect is to give a richer color, and that the attractive color is retained in the butter, even when made in late winter. Not a single report has been received indicating that the flavor of either the milk or the butter from cassava-fed cows is affected in the slightest degree.

Increase of butter.—While it is not probable that the feeding of cassava increases the percentage of butter fat in the milk, Southern dairymen agree in the statement that a gallon of milk from a cassava-fed cow will make more butter than an equal amount of milk from the same cow when on other feed. Though no accurate tests have been made to determine what influence the feeding of cassava has on the creaming of milk, the experience of a large number of dairymen agrees so closely as to make it more than probable that this feed does modify the milk in such a way as to cause a more nearly complete separation of the cream, and, perhaps, a more complete separation of butter in churning

also, so that there is less loss of fat in both the skim milk and the buttermilk.

Firmer butter.—When milk is to be used for making butter, it is a common practice to add a little cotton-seed meal to the ration, both for the large proportion of protein which it furnishes and also to make the butter harder. Some feeders add wheat bran or shorts also, but cotton-seed meal is the better article, as so much less is required to balance the carbonaceous cassava that it is less expensive. It is a well-established fact that when cows have cotton-seed meal for a part of their ration the melting point of the butter made from their milk is several degrees higher than in butter made from a ration of wheat bran, shorts, or other common grain feeds. The region where cassava can be grown is a region with long summers and without the cold springs of the northern dairy regions, so that here it is only good practice to use such feeds as will keep the butter firm under ordinary conditions. Cotton-seed meal is such a feed, and its solidifying effect on the butter makes it the best grain feed for the Southern butter maker. Its highly nitrogenous character makes it specially useful for feeding with cassava.

Methods of feeding.—Cassava can be fed very liberally without endangering the health of an animal, some feeders using as much as a 10-quart bucketful twice daily. In feeding to cows and to beef animals the roots should be cut or broken into small pieces to prevent any danger from choking, though this is not necessary when feeding to horses and hogs. Some crush the roots by laying them on a block and pounding them with a mallet, and as the fresh roots are very brittle the work can be done very quickly. Others put the roots in a box and chop them with a spade, while a root cutter, such as is used in slicing turnips and sugar beets, is still better.

Value in fattening cattle.—The very large proportion of starch which it contains makes cassava specially valuable in fattening cattle, as it not only furnishes the elements necessary for the production of fat, but it also furnishes the fresh and succulent feed needed to keep the animals in their best and most thrifty condition. When velvet bean or peavine hay can be used for roughage no grain need be used, but with other hays and when the animals depend on grazing for roughage it is better to add a small amount of cotton-seed meal to the cassava to provide the required amount of protein.

Dr. Stockbridge reports, in Bulletin No. 49 of the Florida Experiment Station, that in a test made at that station an animal made a heavy gain when the ration was made to include 15 pounds of cassava and 2 pounds of cotton-seed meal. "To meet Florida conditions, hammock pasture, supplemented with an occasional feeding of peavine, velvet bean or crab-grass hay furnished the coarse fodder, and no shelter was supplied or needed during the feeding period, which included seventy-

five days, ending February 19, 1899." During the seventy-five days of the test the animal consumed 150 pounds of cotton-seed meal and 1,125 pounds of cassava. The cost of these two feeds was $2.62. The animal made a gain of 276 pounds, which, at 4 cents per pound, gave a total increased value of $11.04, or a net profit of $8.42, if the value of the manure is regarded as an offset to the value of the roughage consumed and the labor involved in the care and feeding. This makes the net cost of the increase in weight a trifle less than 1 cent per pound, which is certainly a remarkable result.

In 1901 a firm operating at Muscogee, Ala., fattened 200 head of cattle, using cassava in place of grain. Nearly all of the animals were fattened and marketed with no grain whatever, though a few which for some reason were not doing well received 1⅛ pounds of cotton-seed meal per day in addition to the cassava. In this case 1,600 pounds of cassava were fed daily, the roots being sliced in a root cutter. The cost of the work, including the digging of the roots, hauling them 1½ miles, cutting them for feeding, and the storing away of the seed canes for planting the next year, was $3.60 per day, or $4.50 per ton for the roots used. The digging alone cost about $1 per ton, or the labor of one man for one day. In addition to the beef animals, 100 hogs were kept in the same feed lots and became almost too fat for the best quality of pork, though they received no feed whatever except what they picked up about the feeding troughs and in following the steers. These hogs would leave corn uneaten at any time when they could get cassava in its place.

This firm grew 25 acres of cassava in 1900, 50 acres in 1901, and planned for 75 acres in 1902, but lost a large part of its seed canes in the winter of 1901–2, so that the actual present acreage shows a decrease from that of last year. All of the seed canes grown on the place this year have been stored for planting in 1903, when it is hoped the acreage may be increased to at least 100 acres.

Others who have used cassava for fattening smaller herds, or perhaps for only one or two animals, make equally favorable reports of its good qualities, and all of those who make any comparisons of cost regard it as being much less expensive than corn or any other grain feed, though many recommend the addition of from 1 to 2 pounds of cotton-seed meal to the daily ration.

A dairyman at Florahome, Fla., says:

> Before using cassava I fed cotton-seed meal and bran, one part of the former to three of the latter, making a 6-pound ration. The cows were turned out daily to feed on the saw-grass and wild millet which grows on the muck land surrounding the hammock on which this place is located. Owing to the decline of the pastures, which have been getting worse and worse since September, the cows shrank in both milk and butter. I commenced feeding cassava about 6 weeks ago, and almost immediately noticed an increase in milk and butter, and a marked improvement in the color of the latter, besides its being of a firmer and harder texture, as well as of

better flavor. I am feeding about 10 pounds of cassava and 1 pound of bran to each cow twice daily. I feed the cassava raw, and, after washing it to free it from sand and dirt, chop it into pieces about 2 inches long and mix the bran with it, together with a tablespoon of salt every morning. The yield on this hammock land runs over 6 tons per acre. Two men and a team can readily plant 2 acres per day, perhaps more. I regret that I can not reply in regard to the relative feeding values of corn and cassava, but am of the opinion that when exact methods are adopted to settle the matter, cassava will be found nearly equal in feeding value.

FEEDING TO HOGS.

Nearly everyone who grows cassava uses it to a greater or less extent for feeding hogs. In some cases the hogs are turned into the field and allowed to gather the whole crop for themselves, and, while this method is very satisfactory so far as the fattening of the hogs is concerned, it is not the most economical of feed, as many roots are pulled out of the ground and left, where they soon decay. Where the supply of roots is not considerably greater than can be used to advantage, it is much the better plan to dig them and feed only as fast as they are eaten. In every field where cassava has been grown there are always many broken roots left in the ground after the crop has been gathered, and these will soon be found by hogs when they are turned into the field; but, excepting in such cases, it is seldom a good practice to allow the hogs to do the harvesting.

While there is less waste when the roots are sliced or chopped before feeding, hogs do not become choked, as cattle sometimes do when fed on whole roots, so the cutting is not essential to safety.

Cassava is too carbonaceous to be the best feed for growing pigs, and when fed to such animals should always be mixed with shorts, bran, peas, or some other nitrogenous food which will furnish material for bone and muscle. When fed on an exclusive diet of cassava, hogs fatten very rapidly and soon become too fat for making the very best quality of pork, while their growth is very slow and unsatisfactory. When the hogs have the run of a field of cowpeas, velvet beans, or peanuts, they will secure so much nitrogenous food that they may safely be given all the cassava they will eat. Hogs eat it greedily, and prefer it to corn when both are placed before them.

Many feeders use cassava exclusively during the fattening period, after the animals have reached sufficient size, and find it very satisfactory. The pork is very white in color, of fine flavor, and, though perhaps not quite so firm as that from corn-fed hogs, is much more firm and shrinks less in cooking than that from animals fattened on cowpeas or peanuts. When kept for a considerable time on cassava feed alone, it is better to make half the feed of corn or rice bran during the last two or three weeks before butchering, though this is hardly necessary when they have the run of a good pasture.

Last year a few hogs were fattened at Lake Mary, Fla., their feed being four parts of dry waste from the starch factory and one part of shorts. On this feed the animals made an excellent growth, were well fattened, and the pork was remarkably sweet and good. Fresh waste from the factories has been used to a small extent, but it is too watery and too troublesome to handle to make it of much value.

The fattening of 100 hogs following 200 cassava-fed steers at Muscogee, Ala., has already been mentioned, and if that method is equally successful in other places it certainly produces pork at a very small expense. Feeders who have made somewhat careful tests regard a pound of the fresh roots as being worth from one-half to two-thirds as much as an equal weight of corn in making pork, and are quite generally agreed that during the growing period a small amount of shorts or bran should be added to the ration, or that the pigs should have good pasture, while during the last few weeks of fattening a small proportion of corn will produce a firmer meat than when cassava is the only feed.

Dr. Stockbridge states, in Bulletin No. 49 of the Florida Experiment Station, that when five lots of pigs were fed a period of seventy-five days, cassava gave a greater net profit and a greater percentage of gain than did either corn, chufas, or peanuts, and a greater net gain in weight than did any except corn. The cost of the increased weight of the cassava-fed pigs was only 1.04 cents per pound, while the increase of the corn-fed pigs cost 3.06 cents per pound. In these tests the cassava was charged to the pigs at the rate of $6 per ton and the corn at 60 cents per bushel, these prices being somewhat more than the actual cost of growing the cassava and less than the usual market price of corn in Florida.

A grower at Wortham, Miss., states that he regards 1 acre of cassava as being worth as much as 8 or 10 acres of corn for fattening hogs, and thinks it the cheapest feed which can be used when hogs are grown for market. Last year, on October 15, he shut up three lots of hogs, all of the same breed and of nearly the same age and weight. One lot was fed with cassava, one with corn, and one with a mixture of meal and shorts, equal weights of each feed being used. The hogs were killed near the end of January, and it was found that the cassava-fed lot had made the greatest gain, having made 110 pounds for each 100 pounds made by the corn-fed lot. The cassava lot were then really too fat, having more fat and less lean meat than the corn lot, and a still greater difference in fat over the lot on mixed feed. The cassava lot had seemed slightly "off their feed" during the last two or three weeks of the test, which was continued longer than was desirable, on account of warm weather. Their meat, however, was very white and more firm than that from the corn-fed lot.

FEEDING TO POULTRY.

In localities where it is grown, cassava is used more commonly than corn in the feeding of poultry. It needs no preparation before feeding, as the roots are so tender that they can be eaten readily, and poultry eat them as greedily as do other kinds of stock. When fed alone cassava makes hens so fat that they do not lay well, as is the case when they are given an exclusive corn diet, so it is better to mix it with wheat, oats, or some similar nitrogenous feed. It is unsurpassed when fowls are to be fattened for market, as it makes a rapid increase in weight with very small expense.

One poultry raiser at Orlando, Fla., who keeps from 500 to 700 fowls, states that he has fed cassava since 1885, and that it is the most inexpensive as well as the most satisfactory feed he can find for use in the place of corn, though it is not so complete a food as is needed by growing chickens and laying hens. Others who have used it for feeding poultry make similar statements, and it is the general experience that when it is used as the principal food from one-third to one-half a feed of wheat or oats should be added to the ration, and that the feeding of cassava saves fully one-half the usual cost of corn.

USE OF FACTORY WASTE AS FEED.

Value of waste.—While the fresh roots contain from 24 to 28 per cent of starch, the factories now secure only about 20 per cent, so that about 25 per cent of the original starch content is left in the waste. The extraction of four-fifths of the starch leaves the waste with a composition very similar to that of corn, but as no digestion tests have been made with this substance, or even with the fresh roots, there are no means of knowing exactly what its feeding value may be. The waste as it comes from the settling vats has a very large percentage—from 60 to 80—of water, most of which must be removed before the waste is in a condition in which it can be handled. A large part of the water is easily removed by filtering and pressing, and the "cake" which remains is then readily dried and prepared for use.

The factory at Lake Mary, Fla., prepared a considerable quantity of this waste last year and found a ready market for it for from $10 to $12 per ton. It was used for feeding horses, cattle, and hogs, and was so satisfactory that the demand exceeded the supply. While no accurate tests of its feeding value have been reported, it is in such excellent mechanical condition, its nutritive ratio is so high, and it is eaten with such relish that it should be well worth the price for which it is sold.

The waste does not contain sufficient protein to make it an ideal feed, and it will not wholly take the place of grain feed for working animals or milch cows, but it certainly has a high value for fattening

animals and for mixing with more nitrogenous feeds, like oats, bran, or cotton-seed meal.

Problem of marketing waste.—The proper utilization of this factory waste and placing it on the market is a matter of great importance to the future of the cassava industry, as each ton of the fresh roots will produce about 330 pounds of dry waste, which, at $12 per ton, is worth about $2. From the work which was done in that line last year, it seems probable that the cost of drying and preparing it for market need not exceed one-third of its selling value, thus leaving a good profit to the manufacturer. The present factory price for the roots, $6 per ton, is too low to stimulate a wide cultivation of the crop, though the factory managers claim that the present prices for starch do not justify them in paying more. The utilization of the waste, however, would add very materially to the profits of the manufacturer and so enable him to pay a better price to the growers.

The fresh waste contains so much water that it can not be hauled or handled conveniently for feeding, and as it becomes soured within a day or two after it is made, it must be dried at once to be made available. As the factories can run only about three months in each year, they are greatly crowded with work during the season, and so hesitate to add another and an almost untried line of work to their present business. From the beginning made last year the results were so encouraging that it is planned to do still more in the same direction this season, and it is highly probable that dried cassava waste will, within a very few years, become a staple feed in localities near the starch factories.

In Brazil it is a common practice to grind and dry the roots so that they may be stored or shipped and be available for use as feed at any season; but no attempts have been made to follow that practice in this country, though there appears to be no reason why it should not be as profitable here as elsewhere. A grinding and drying outfit is far less expensive than a starch factory, and the product would be a valuable food, containing about 85 per cent of carbohydrates and 3 per cent of protein. Such a feed would find a ready market in every town with those who keep one or two horses or cows and have no land upon which to grow feed for them. Several persons in southern Florida are now considering the advisability of erecting plants for such work.

CASSAVA FOR STARCH MANUFACTURE.[a]

PROFITS AND MARKET.

Although cassava is the principal starch-producing plant of Brazil and other South American countries, and although it has been used

[a] A thorough study of cassava was made in the Bureau of Chemistry in 1894, and published as Bulletin No. 44, now out of print. A considerable part of the data obtained is incorporated in Bulletin No. 58 of that Bureau, printed in 1900 under the title "The Manufacture of Starch from Potatoes and Cassava."

very commonly for many years for making starch for domestic uses in Florida, its use for the manufacture of starch on a commercial scale was not undertaken in the United States until 1898, when a factory was established at De Land, Fla., this being followed by the establishment of another factory at Lake Mary in 1899. Both these factories appear to be profitable business enterprises, and it now seems probable that others will be erected in the near future. Up to the present time these factories have confined their operations to the manufacture of starch only, no attempt having been made to produce tapioca, glucose, or other products which might be made from the roots. None of the starch made at these factories has been offered in the retail market, all being sold to cotton factories, where it is used in making sizing for various classes of goods. Those who have used it for laundry purposes claim that it is much better than starch made from corn or potatoes, giving a smoother surface and a finer gloss than can be obtained by the use of either.

SUPPLY OF CASSAVA ROOTS AT FACTORY.

Up to this time the price paid for roots has been about $6 per ton delivered at the factory, or $4.50 per ton in the field, the average cost of digging and hauling being about $1.50 per ton. Many of the growers contend that at the present price there is little profit in growing the roots, while the factory managers assert that they can not afford to pay more, as they are obliged to sell their starch at a price which enables them to compete with the manufacturers of starch from corn and potatoes.

A considerable acreage was grown under contract for the factories in 1900 and 1901, but less in 1902, when the factories increased their own acreage quite largely and now propose to make a still larger increase in 1903, one factory having stored seed canes for planting 800 acres. Where growers have secured full stands of plants and a good yield of roots (6 tons or more per acre), and the haul to the factory has not been too long and expensive, they have made fair profits, and many of them are renewing their contracts. Many others, however, are finding it more profitable to use the crop in the feeding of some kind of live stock, and do not care to renew contracts with factories for less than from $6.50 to $7 per ton. The general experience of the most extensive growers indicates that the present factory price for the roots is not sufficient to make the crop more than ordinarily profitable, except when grown on unusually favorable soil and in locations where the hauling can be done at a slight expense. As the factories do not depend wholly on the profit in growing the crop, but on the profits of its manufacture into starch, they can still afford to grow it at an expense equaling its present market price.

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